

Masters Program in **Geospatial Technologies**



BEHAVIOR MONITORING AND BEHAVIORAL EXCHANGE ***An approach from geospatial technologies involving gamification techniques***

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BEHAVIOR MONITORING AND BEHAVIORAL EXCHANGE

An approach from geospatial technologies involving gamification techniques

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ABSTRACT

In the last years the concerns about ecologic problems derived from human activities and CO₂ emissions have increased, leading population to a rising awareness on green behavior. This paper discusses an approach to the evaluation and exchange of the green behavior of a community from the viewpoint of a project in the frame of smart cities, where the flow of information among the members of the community becomes a basic part of decision making. This approach is developed from a perspective based on mobile technologies, with the application of gamification techniques in order to get the community involved in the process of data acquisition, and with the final goal of making possible a behavioral exchange of the members of the community.

KEYWORDS

smart city

smart campus

behavioral exchange

mobile application

gamification techniques

ACRONYMS

CO₂ - Carbon dioxide

GIS - Geographic Information System / Science

ICT - Information and Communication Technologies

IEA - International Energy Agency

UJI - Universitat Jaume I

UN - United Nations

VGI - Volunteered Geographic information

ViscaUJI - Virtual Smart Campus Universitat Jaume I

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CHAPTER 1: INTRODUCTION

In this work is presented a project to develop a serious game in order to collect geographic information from the members of a community, and aiming to reach a mechanism of behavioral exchange. This project was developed in the frame of the Master of Science in Geospatial Technologies, in order to fulfill the requirements of its final thesis, by the student David González Sánchez.

Motivation of the project

Since the decade of 1980 scientist have been concerned about climate change and global warming consequences, but it is in the last two decades when the concerns about climate change have extended to a large part of population. Some climatic phenomena, such as cold/heat waves and hurricanes made people realize of the possible implications of climate alterations, and how can human actions be implied on them. Scientists warned about the implications of the raising of greenhouse effect gasses, specially CO₂, which is the most common greenhouse effect gas, and is produced by most of the industrial processes.

Following these concerns, and based on scientific studies, even some politic procedures on CO₂ emissions reduction have been elaborated, even if most of them never were adequately implemented, as in the case of *Kyoto protocol*. These protocols have not reached their objectives for the moment, but obviously, public concerns about CO₂ emissions have increased dramatically. Today it is quite usual to hear about terms as *ecological footprint* and *carbon footprint* (**Wiedmann2008**) and their implications on economy and industry.

On the other hand, many scientific studies are also warning about another silent problem, not so spectacular as climate change, but really important for industry and economy: the exhaustion of natural resources and especially the oil exhaustion.

There are many different hypotheses about how much oil is still remaining, and how much time do we have before the exhaustion, but today there is no doubt about the fact that oil is a non-renewable energy source (**Hall2008**). Even keeping far away from *peak-oilers* and *preppers/survivalists* doctrines, there are many scientific studies on this field, and today the future exhaustion of oil production is considered a fact, where the question is not whether it will happen or not but when will it happen, and even mathematical models have been designed to go in depth on this question (**Mohr2008**). It is important to mention that the International Energy Agency (IEA), publishes yearly an inform (the World Energy Outlook), and some studies based on these publications (**Aleklett2010**) revealed that international oil production became practically constant in the last years, and the prognosticated increment of production will be quite similar to the increment of the demand, but not allowing bigger increments. These factors can explain the raise of costs of the energy in the last years, and draw a future of expensive energy, with special incidence on gas and fuels.

On a situation of economic crisis, enterprises need to reduce their production costs and citizens need to save money in order to keep their consumption capability, which is desirable not only for citizens, but also for general economy, because the more consumption capability of citizens, the more products selling of enterprises, and the more jobs are generated. On such a situation, the raise of the costs of energy can be disastrous. So, it is important to aware citizens on the problems implied on energy costs, and the importance of saving so much energy as possible, on the industrial processes as well as in the daily life of each simple citizen.

Even if it is possible change some productive processes in order to move from oil-based energy to other kind of power sources, it is not possible in the field of transportations. All the merchandises and travelers have to be transported by conveyances using, in most cases, gas or fuel, and the availability of other kind of transportation based on other energy sources is really little. Even in the case of some hybrid or alternative vehicles, the need for power is frequently compensated with oil-

based processes. So we can assure that transportations is a field where saving fossil fuels is a hard task, that requires the collaboration of all the people implied. In the case of transportation enterprises, this problem becomes a profits issue, so it is easy to persuade them of the advantages of saving oil, since it has a direct impact on their balances.

In the case of travelers it is not so easy. There are many factors implied on the behavior of travelers. Some travelers have a good knowledge about the environmental situation, and they are strongly aware or even concerned about, but in most cases this is not the case. Furthermore, the transportation habits, or the comfort during the trip are sometimes decisive arguments, better considered by far.

That makes clearly realize of the importance of getting a behavioral exchange of the users of transportation systems, tending to reduce their fossil fuels consumptions, by performing initiatives in order to enlarge users awareness on the problems involving transportation systems and the importance of saving energy and establishing patterns of green behavior that could easily be adopted by them. The size and implication of this problem is huge, and it would require larger much more work than could be faced on this project to reach only a small positive result. In order to get an affordable scenario for this project, the scope of the problem should be reduced, as will be further discussed when describing the context of the project.

Among the different possible initiatives, and focusing on the field of geospatial technologies, this project aims to develop a tiny application to help users to realize of the impact of their transportation habits, and offering them a feed-back on their behavior, contributing in this way to improve their awareness on this field, and helping them to get a behavioral exchange tending to reduce their *ecological footprint*. Moreover, it would be desirable to get a large collection of data about transportation habits of the community, in order to a better decision making to support future actions on energy savings initiatives.

There are different possible approaches to this objectives, depending on the purposes, the target user and the collaboration capability and motivation of them. To get the users involved in the initiative it is necessary to motivate them, and the approach adopted by this project is based on the development of a *serious game* (Susi2007), as will be carefully discussed on the point referred to the gamification process.

Context of the project

As previously explained, the aim of the project is the development of a gamified application to make increase the users awareness on the environmental problems implied in transportation issues and at the same time, getting information about the transportation habits of the community. But in order to reach this objectives, the first step is defining the scope of the project.

Dealing with this problems, aiming the mentioned objectives, need for the concept of community where this project is being developed, since the target users are part of a community, and the travels and information to be recovered are referred to the space where that community develop their activities. In the last decades the concept of city as the place where human activities are developed has changed dramatically. Traditionally most of the population used to live out of the cities, and cities where economic and administrative centers of activity. But paying attention to the statistics of the UN (UN2012) nowadays more than 40% of the world population is considered urban population, and this percentage is tending to grow.

Such a growth makes increase the needs for a better planning and control of the resources in the city. That need for control of the resources led many governments and institutions to the development of data infrastructures to warrant the flow of important information (Batty2012) and to improve the supervision and maintenance of the infrastructures. Along the last two or three decades many

initiatives have been taken in the field of the smart cities, understanding this as cities using the advanced Information and Communication Technologies (ICT) to improve the administration and management. In the case of the European Union, ICT and advanced networks are considered the cornerstone of the smart city concept (*Caragliu2009*).

Moreover, since the Internet appeared in the early 90s, the combination of Geographic Information Systems (GIS) and the advanced networks has increased the amount of geographic information and services (*Fu2011*) up to levels impossible to imagine two decades ago. This GIS enhancement, and the extensive use of different data resources (such as online databases and services, crowdsourcing platforms and sensor networks) make available a large amount of information about environment, networks, energy, communication and all the fields of human activities. And this amount of information, adequately managed, is a valuable resource to help in the administration and management of a smart city (*Batty2012*).

Despite the increase and spread of sensors networks, that have make them almost ubiquitous, it is still difficult having sensor networks to monitoring every feature required. So, in order to get the desired amount of information for the control and managing of some features of a smart city, it is necessary to found some other resources. In this field, volunteer information (Volunteered Geographic Information or VGI) and crowdsourcing are possibilities to seriously consider. Since the arise of social networks, the concept of community have been developing and evolving, becoming more and more important each time, and nowadays crowdsourcing initiatives are a vibrant topic in many areas.

Based on this concept of community of users, it is possible to find a slightly different approach to the monitoring-based GIS. Even if there is no availability of sensor networks for some activities, if those activities involve the participation of human beings, it is always possible to ask to the involved community of people for information about them. In this case, crowdsourcing platforms and especially mobile

applications can be valuable possibilities to allow communities of users to share their information.

The potential utility of such a system would be limited only by the quality of the knowledge database and the source of data to operate with. This could be useful to help in the management of the transportation systems into a smart city as well as to control some traffic features of a transportation network of a company, a region or a country. For the project proposed in this paper the testing bench will be the smart campus project of the Universitat Jaume I (UJI). The Riu Sec campus has a surface of 756.566 m², with 15 buildings (and some others being built), with a total of more than 14.700 students. Five different bus lines arrive to the campus, and every day thousands of cars are driven through its 12 streets. The dimensions and needs of this whole community allow thinking of this institution as a little city with similar problems to many other cities in the world.

The *viscaUJI* (Virtual Smart Campus for the Universitat Jaume I) project is a project that is being developed at the University Jaume I in order to provide a complete SDI of the UJI campus and different functionalities. The project will incorporate not only geographic information about the campus, but also different applications to get that information and to exploit it. The application developed for this project will be incorporated to this project as an application to collect information from the users and also to give them information about the UJI transportation systems and problems.

In this context the information resources of the system to build will come from the students (and the rest of the community), that will be transmitted to system through the use of the game. By using this app, the users will get a feedback on their behavior, and at the same time they will provide the system with information about their transportation habits. This information will be stored on the ViscaUJI databases, and even if it will not be used in the context of this project, it could be a starting point for future projects, facing some simple decisions making, particularly

related to the transportation network optimization, and building a platform of GIS-based decision making to be extended with the experience and knowledge provided by the community to enhance the management of the facilities.

Goals and objectives of the project

As previously described this project aims a double objective: on the one hand to increase the users awareness on ecological issues around the transportation habits, the final aim of this work is help to improve the green behavior of the community. On the other hand this project will try to provide the managing crews with information about the behavior of the users related to their habits of transportation, information that will be useful later for managing tasks.

In this case the information required is about the current behavior of the users, how they arrive from their original location to the campus (and vice versa), where are those other location, their habits on this matter, and departing from this information the developed system should provide the users with suggestions about ways to reduce the ecological impact of their actions, and in the same way the system should offer some kind of stimulus for behavior exchange. This information is interesting for the managing crews in order to better know the current habits of the community and how the transportation lines are being utilized currently, and also to develop strategies for a better planning of the transportation lines and traffic infrastructures.

CHAPTER 2: BIBLIOGRAPHIC REVIEW

Once all the desired requirements have been specified, and a first approach to the nature of the project is drawn, it is necessary to decide a technological approach to these features. A good departing point for this project could be a bibliographic review on previous experiences on the same or similar fields of application. Concretely, previous experiences in the fields of crowdsourcing based GIS, crowdsourcing through the use of mobile applications, and motivation of the users and gamification techniques applied to these fields.

Review on previous experiences

As previously explained on the description of the context, the importance of the cities as places where human activities take place led to new organization concepts, and since the incorporation of ICTs to the managing systems, through the incorporation of intelligent systems based on the use of information coming from different resources involving the different activities on the city, the cities got *smart cities*, arising a new concept of organization (*Caragliu2009*) involving the whole community in the managing of the structures.

Following this way, it is possible to find previous descriptions of systems and experiences on applications monitoring any aspects of the life on a city. Among them, experiences based on mobile applications and crowdsourcing can also be found. Crowdsourcing based GIS are nowadays a vibrant topic (*Goodchild2007*). The concept of citizens information recruiting has been incorporated to the design of GIS and have been revealed as an important source of information in many fields, and even sometimes a good way to substitute or complement sensors networks and observation stations. Since many initiatives such as Wikimapia or OpenStreetMap became well-known initiatives, the collaboration of the community with this open

source initiatives became a source of information with a high standard of quality, and currently even enterprises like Google or ESRI have initiatives to build users communities in order to allow them to share their VGI. Moreover, the importance of VGI in the disasters managing have been observed several times by disaster managing crews, and the possibility of sharing VGI through social networks and Web 2.0 services has been revealed as a valuable information resource about disasters (*Nuñez2011*). Even the European Union incorporated the VGI as a part of the resources of the project EuroGEOSS (*Díaz2012*), taking advantage of the information shared by citizens on social networks.

Within the frame of the Erasmus Mundus Master Program in Geospatial Technologies, and in this same field of VGI based GIS, involving the community on the recollection of information, a project of a public participatory GIS was developed on the city of Canela, Brazil, on 2009 (*Bugs2009*). The project aimed to recover as much information about urban planning topics as possible, not only from official resources, but especially from the community. This project made available a simple Web 2.0 application to the citizens of Canela in order to share their VGI about urban planning topics. As a result of the experience the project recollected many information on all the urban planning topics from the community of citizens, complementing in this way the official one.

Linking this field of VGI and crowdsourcing with the use of mobile devices applications, was developed the NoiseTube project (*Maisonneuve2009*), a project for noise pollution monitoring in the frame of the European Noise Directive. In order to perform this noise pollution monitoring the project aimed to recruiter the collaboration of the citizens, by using their mobile devices to take measurements on the noise pollution. This project was based on the development of a mobile application to be used by the community of users, who voluntary collaborated by using this application to take measurements on the environ. This measurements were taken, processed and sent to the servers with the corresponding geotagging information in order to complete a noise map, based on crowdsourcing.

Of course, the problem of this kind of developments, based on crowdsourcing, is the motivation of the users. In this sense, another experience, departing from the same objectives of the previous one that can be found on the bibliography is the NoiseBattle and NoiseQuest projects (*García2012*). In this case the aim of the project is the same: getting VGI from the users about the noise pollution on the environment, in order to complete a noise pollution map, based on crowdsourcing. But in this case, the strong point of the project is the use of *gamification techniques*, that involves the design of an application under the appearance of a game, in order to motivate the users to participate, getting involved in this way on the project. The two developed applications focus on two different kind of users (defined as *explorers* and *achievers*), and are especially thought and developed to motivate them.

These few experiences can be seen as a departure point for the purposes of this project, involving either similar purposes or similar approaches to these that we want to face in this project. After reviewing these cases the employment of gamification techniques appears as a good point to be reviewed in depth.

The process of gamification

As a result of the initial contextualization and the bibliographic review, the gamification techniques appeared as a good approach to face the motivation of the users. With the objective of better exploring this option, it is necessary to study in depth the relationship between motivation and gamification techniques.

A popular and brief definition of the concept of *gamification* can be found on the Wikipedia as "*Gamification is the use of game-thinking and game mechanics in a non-game context in order to engage users and solve problems*" (*Wikipedia2013*). Going in depth in this concept, another definition that can be found on the e-learning platform Coursera is "*Gamification is the application of digital game design techniques to non-game problems, such as business and social impact challenges*"

(Coursera2013). From this definition is started a bibliographic review in order to get more information about the different concepts involved on this topic.

Gamification concepts

Every project involving a software development needs of a careful design process. In this process not only technical aspects have to be considered, but also the point of view of the users that will work with the system. The more interaction between the system and the final users, the more respectful should the design be with their preferences. Most of the problems of the daily work with the system could be avoided with an accurate design taking into account the final user preferences or, at least, avoiding designs that could be uncomfortable to them.

Crowdsourcing projects like this, especially based on the participation of a community of users, require a very careful design process in order to get the community as involved as possible on the project, because the final success of the project will depend on the amount of information provided by the community. Even if the target user has a strong intrinsic motivation a good design might help them to participate, and of course, an attractive experience is the best tactic to catch their attention (*Vassileva2010*). From this point of view, an attractive interface design, easy to employ is important to guarantee a comfortable experience. But in order to keep the users involved, can be useful the addition of some stimulus appealing to their social preferences, and why not, trying to transform the use of the system into a kind of amusing experience.

From the perspective of the designer, the use of gamification techniques imply adopting design decisions taking into account the motivation of the users, in order to design a sort of *market mechanism* based on incitements, actions and rewards to get the users involved in the action of the game (*Vassileva2010*), adopting a game economy based not only in extrinsic motivation, but trying to balance

intrinsic and extrinsic motivations by paying attention to the different kinds of players.

From the perspective of the users, the designed game should take profit of their motivations and fields of interest, and engage them by the use of attractive interfaces and a stimulating game, with rules and a rewards mechanism adequate to catch their attention.

Motivation of the users

The main goal of this project is awaking the users awareness about environmental problems involved in their habits of transportation, and help to improve their green behavior on this matter. In order to reach these objectives, the application to develop should involve the biggest possible number of users of the community, and stimulate them to share their experiences and information, and using the system to get advice.

One important thing to be taken into account is the possible motivation of the different users to collaborate in this initiative, because the design of a system or application should be guided not only by the final purpose to reach, but also by the preferences of the users, that should be the guideline to establish a better design approach. In this field, the application of gamification techniques is a good practice to make the users get involved in the project.

In order to design a better gamified application the different possible players profiles should be consider to take into account their potential motivations. As a guide to consider these motivations one point of view is departing from a classification of the roles that players can adopt (*Bartle2012*):

- Achievers: They tend to achieve a goal. They like to complete levels of a game and make their scores rise up. They interact with other users in order to get help for their achievements.
- Explorers: They like to explore the world, and enjoy discovering how things are working. They can interact with other users to interchange information and impressions about the world.
- Socialisers: They are especially interested in people and like sharing their experiences and relating with other players as a goal itself
- Killers: Their goal is to dominate over the other players

Implementing an application involving all this kinds of users might be difficult, especially thinking about the final purpose of it. But departing from this classification it is easy to see that players tend to relate with other players and interchange their experiences (except by the last type of player, hard to socialize). To get the maximum number of users an application should be designed to be attractive for the biggest number of users.

In the concrete case of this work the application to design aims to get the collaboration of users to collect information about their green behavior, that means that people involved in this kind of cause will be more collaborative than competitive in their final motivations, but it is an interesting task for the designer create an application suitable to take profit of the natural tendencies of the different possible roles of the players.

CHAPTER 3: ANALYSIS

With the motivations explained on the introduction, and considering the experiences reviewed on the bibliography, the next step is analyzing all the requirements and building the structures based on that analysis, evaluating the different technological possible approaches.

Functional analysis

Once the motivation and objectives of the project are clearly defined, the next step to consider is the specification of the functional requirements of the project, and the resources to be invested on it.

The motivation and objectives of the project have been clearly discussed on previous points, and we can define the objective of the project as the development of an application oriented to increase the users awareness on environmental problems involved in transportation systems and boosting a behavioral exchange on the users. Of course, such an ambitious objective has to be reached within the limits of the context where the application will be developed for, in the case of this project, as was previously commented, the context is the UJI *smart campus*.

Within this context, it is necessary to specify the field of study. Since the objectives involve the transportation habits of the community, it seems to be clear that the scope of the project might focus on the way in what users are moving, and in this issue, the most interesting type of travels is how the members of the community reach to the campus from their original locations, and how they go from the campus to their destinations (either their homes or other), involving in this way not only the infrastructures of the university, that are not very large and not meaningful to consider for this study, but also all the infrastructures required to reach the campus from other locations, meaning a much bigger area, where conveyances should be required, implying in that case the possibility of significant ecologic impacts.

With this scope the project aims to increase the user awareness on this problems, and the next point to consider is how to reach this objective. In this point there are two possible considerations, on the one hand, the user might need advice about how to behave, and the possible implications of their actions. On the other hand, the user should have a feedback on their actions, allowing them to enhance their green behavior.

Translating this point to the context of the project, this might imply the possibility of the user to ask to the designed system for the best option to reach the campus from their original location (or vice-versa, the best option to go from the campus to other location), and the system should provide the user with some information about the best options available, taking into account related factors, such as distance or fuel consumptions. On the other hand, the user might inform the system about their travels to/from the campus, and the system should return a feedback about the correction of their actions, and an evaluation of the green behavior of the user. Of course, all the information relative to these green behaviors should be stored by the system in order to perform future studies.

In order to assure a good access to the system in all the possible scenarios where could be useful, it is clear that the system should be available at every required time and situation, not only on a determinate location with a PC, but in any place, either indoor or outdoor, and when planning a travel as well as during the travel. Only in that case the potential utility of the system could be completely exploded. Of course, the derived implication of this fact is the need for a technology non place dependant, that actually means the possibility of using mobile devices and platforms, and internet mobile accesses, in order to guarantee an immediate and ubiquitous access to the functionality of the system to be developed. Not only this, but mobile devices offer the possibility of determining the position of the user at each time, that could be a desirable feature to be incorporated to the system.

But moreover, the interaction between the user and the system has to be not only immediate and ubiquitous, but also simple and attractive. It is necessary to have a simple interface, so intuitive as possible, because the potential motivation of the users could be reduced if it was required a large effort to deal with the system. And it is clearly easier to motivate the users to interact with the system if the interfaces are attractive enough to get them involved, and of course, it will be easier to do by combining the adequate motivation techniques, based on gamification, as briefly exposed previously on the introduction (and as will be carefully discussed later), with the possibility offered to the users of a well-known interface, based on their own mobile platform, with which the user is familiarized. The combination of these two factors allows to perform a both familiar and attractive interface, that will help to keep the users involved in the project.

Conceptual architecture

Next step to cover in the process of design of the system is facing the structure and behavior of the components, but without a concrete technology in mind, allowing in this way further considerations on different available technologies.

With the requirements specified so far it is easy to determine some specific parts of the system. It is clear that the system will require a user interface in order to allow the users to communicate with the system. At the same time, a desired feature is the availability of location services to allow the system to get the position of the user. And of course, in order to deal with all the geographic information, the system will require a GIS, and to store all the information, it will have to employ some kind of Databases. To control the whole system some managing software will have to be developed, and since the application will have to be available wherever the user goes, it is easy to determine that some parts of the services will have to be available remotely. With these requirements, and not taking into account specific features

involving technological issues, the first structure of components of the system is appearing.

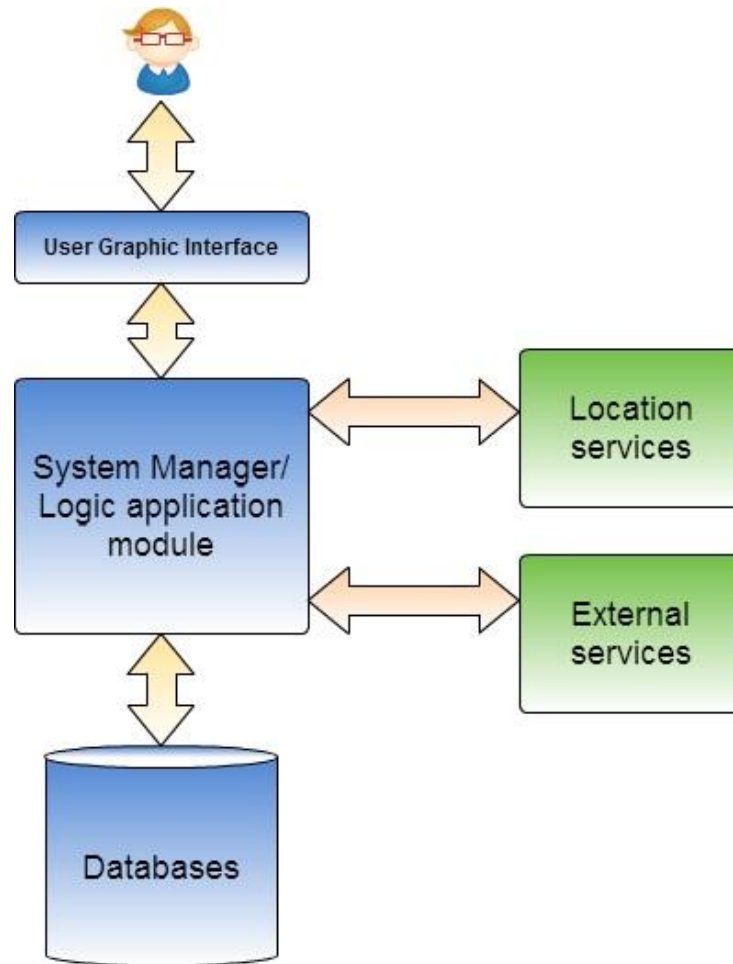


Image 1: Conceptual architecture

The concrete technological aspects are not still faced, so it is not still possible to say where the different components will be placed, and what kind of technological requirements will they have. For the moment, the only things that seems to be clear is that the user graphic interface will have to be directly accessed by users, and some external remote services will be available through communication services.

Technical analysis

After the performance of the conceptual analysis, and having the previous experiences found in the bibliographic review as orientation, the next step will be to perform an analysis of available technologies and an evaluation of the most convenient ones, with the goal of establishing possible approaches with those options.

From the previous analyses the conclusions about the architecture are clear. The system should be simple and available everywhere, with a modular design structured in different components and services in order to allow connectivity anywhere, incorporating location systems easily available indoor as well as outdoor, without adding complexity to the interfaces, and with tools with which the users should be so familiarized as possible.

One approach to fulfill the requirements respecting the modularity consist in establishing a division in two different levels: server side and client side levels. On the server side level will be included all the software required to manage the application and keep data safe, and on the client side all the software relative to the interaction with the users and location issues.

With this division, all the stuff relative to databases, GIS and data maintenance codes will be stored and executed on the server side level, and in the same way, the server side should offer application interface services in order to exchange information with the client side software. Of course the software platforms election should be adopted taking into account the compatibility with the client side technologies, and with the other parts of the smart campus applications.

For the client side software, fulfilling the specified requirements, mobile devices seems to be a good alternative, because mobile devices are tools easily available everywhere, and users are of course familiarized with them, as items

employed on their daily activities. Moreover, mobile device also include location services, that are clearly useful for the purposes of this project.

The question derived from this decision is the most adequate platform for the project development. There are many different mobile platforms on the market. The most popular ones are IOS (iPhone), Android (multiplatform) and Windows Phone (multiplatform). From these three platforms, the two first are by far the most popular, but in the case of Spain (the country where the project is being developed), around 80% of mobile devices are running an Android based platform. This level of market penetration, and the fact that Android is a free-software platform, with no license costs, makes this option the most attractive for the development of this project.

These elections will also have influence on the performance of gamification techniques to be used in this project to get the user involved, because the interaction possibilities will be strongly determined by the hardware and software. For this project some technological features are assumed: the platform will be a mobile device with touchscreen, running an Android platform version 2.3.3 or higher, with Internet mobile access and some kind of location capability (either based on GPS or wi-fi,...). With this features the minimum requirements for the application to be developed will be ensured.

Technical architecture

After the technical analysis, the structure of components should be designed, taking the conclusions of the analysis into account, divided in two levels, client side and server side. On the server side will run all the components required to deal with data and to store all the information, as well as the managing system to keep the system working, at least those parts of the software which are not part of the client side. The client side will be running on a mobile device with the specified features.

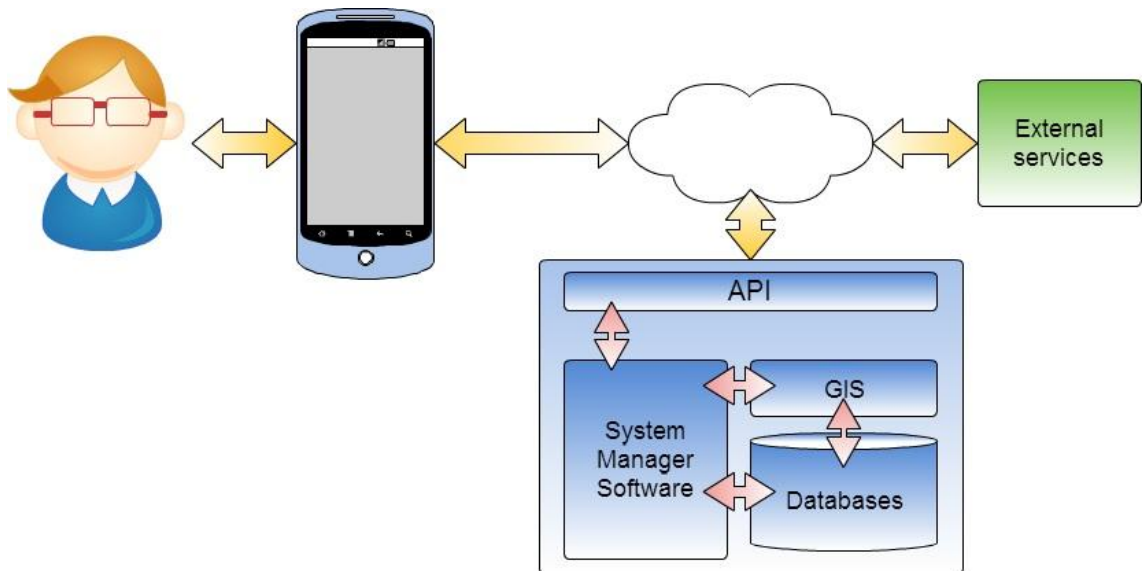


Image 2: Technical architecture

The client side structure of the software cannot be still specified, because its details are strongly dependant on the user interface design. The structure of this level will be discussed during the process of design of the system, when will be discussed also the methodology of gamification employed.

CHAPTER 4: DESIGN OF THE GAME

Advancing in the path of design started with the initial and technological analysis, and considering the perspective provided by the frame of gamification techniques, the next step will be the design of the game where the application will be enclosed. This chapter discusses the design of a game from the perspective of the target users, applying the previously reviewed gamification techniques.

Approach from target user

Departing from the initial purpose of the application and the study of the possible motivation of the users, the next step is attempting to design a gamified application fulfilling the expectancies of the main part of the potential users.

If the project aimed to fulfill the expectancies of all the possible players, the game designed to integrate in the application should allow achievers pursue an objective, as well as allowing some type of world discovery to the explorers, and social interaction to socialisers, and finally the desires of domination of the killers should be accomplished. Of course, attempting to satisfy such a diverse set of roles is almost impossible. So is important to chose only one or two categories of users and focus the game on them.

Due to the nature of the project, based on the idea of crowdsourcing and public participatory GIS and VGI, the easiest roles to match with the goals of the project seem to be those having a collaborative profile. From the classification established, killers are immediately dismissed, because their attitude is critically incompatible with the needs of the project. On the other hand, explorers seem to be the perfect profile for the purposes of the project, because they like to explore the world and sharing information about their impressions, and their expectancies can be easily shared by achievers with the adequate set of rules and rewards. Integrate the

socialisers could be a little more difficult, and only few concessions could be made, so the game will focus mainly on explorers and achievers.

Another point to consider is the topic. Since the final purpose of the application is monitoring of green behavior, nature and ecology seem adequate topics for the game. And the development of the game and the actions of the players should be linked in some way with the purpose of the application.

Following this guidelines the game should offer mechanisms to stimulate the participation on the game through some kind of rewards and taking advantage of the users motivations. Users will participate in the game if their motivations are satisfied in any way. Depending on the initial motivations of the different users, a reward to stimulate their participation should vary, establishing a kind of game economy, that should take into account economic motivation as well as behavioral aspects (*Vassileva2010*). In that sense, the possibility of discovering new items and having information about the correct behavior could be stimulant for the explorers, and at the same time, relating that with the establishment of a system of rewards, related with levels, and a set of rules to progress from one level to another could satisfy the expectancies of achievers. The possibility of publishing game actions on social networks and the availability of a ranking of users and the interchange of items between users could be concessions to make the game more attractive to socialisers.

The concept: "The green garden"

The developed game takes into account the motivations described on the previous point. Summarizing, the designed game has the title "The green garden". In the story book of the game, the user has a garden in which they can grow some plants and flowers. The main goal of the game is having the best garden on the ranking of users (the grass is always greener on the other side of the fence), considering the number and variety of the different species grown on it, and to reach this objective,

the user will have to trade seeds by money, and the possible seeds to be traded will be determined by their green behavior.

Each user starts the game with a small garden and a little amount of coins to buy items, and an initially basic level of knowledge. The garden is divided in squares, and the user can grow one different variety of plants on each square. The garden can be enlarged by buying new terrain if the user has money enough, and the money will be achieved with the different crop harvests.

Each species to be grown has some special features. The seeds of the plant have an economic cost to be paid with coins, but on the other hand, when the user collects the crop they will get a prize higher than the cost of the seeds. Each species requires a certain level of knowledge, and the user will be able to grow those species whose level of knowledge has been reached. Those species whose knowledge level have not been reached by user will remain blocked until the knowledge of the user reaches the required score, and will not appear as option to grow.

The level of knowledge will be increased with a good green behavior. Each time that the user informs of a travel through the application, their green behavior will be ranked according to a table of evaluation, and the obtained knowledge points will be added to their current level of knowledge. In order to evaluate the green behavior of the users, the system will consider the CO₂ emissions generated within the travel, following the table:

Conveyance	CO2 emissions/km (kg)	
Walking	0	per person
Bike	0	per person
Tram	0,042	per person
Train / metro	0,065	per person
Bus	0,069	per person
Moped	0,073	per person
Motorcycle	0,094	per person
Electric car	0,043	per car
Hybrid car	0,084	per car
Gas car	0,178	per car
Diesel car	0,169	per car

Table 1: Evaluation of emissions of a travel

With these data, the application can calculate the total emissions per person of the travel informed by the user. Then, the system evaluates the behavior of the user. To perform this evaluation, the criteria are clear: for short travels the best options are either bike or car, and as the distance grows, the conveyances change towards motorized ones, and among them, the optimum emission corresponds to the emissions per person of a hybrid car (electric cars are dismissed because their market penetration, at least in Spain is non-relevant). In travels of 10 km or less, the optimum emissions level will be always 0 kg, because the considered optimum conveyance up to that distance is walking or bike. In that case the obtained score will be maximum (15 points is the maximum per travel), for the rest, the system will apply a simple formula:

$$\frac{\text{Optimum emissions}}{\text{Informed emissions}} \times \text{Maximum score}$$

This formula will be applied with a maximum score of 10 for travels of less than 10 km and emissions bigger than zero, or with a maximum score of 15 for the rest of the cases, and the result will be rounded to the upper immediate integer number.

Complementing this basic rules, the users will also be allowed to give a part of their collected plants to another user (in this case, the destination user will receive the amount of money equivalent), obtaining 1 extra point of knowledge in this process (with a maximum of 5 per day). All the achievements of the users will be published on social networks if they allow.

The design of the game attempts to satisfy the motivation of the different kinds of users. The game incorporates different objectives (the main goal of having the best garden, the different levels of knowledge required, the economical cost of seeds and terrain...) to stimulate the participation of achievers and explorers, that could feel attracted by the possibility of reaching objectives and experiment with new crops. The gifts have a double purpose: on the one hand is a good way of stimulate the participation of socialisers in the game, and on the other hand, is a way to stimulate the participation of those users whose green behavior is not good. This could initially seems a nonsense, but one of the purposes of the application is collecting information about the biggest number of users possible, including those whose green behavior is not the best, but they will receive a little amount of rewards because of their behavior, and this could lead them to abandon the game by tiredness or bore. The game must not reward bad green behaviors, but should stimulate even those users with bad behavior to keep on participation, and offering them the possibility of having a slight reward by socializing with other users is a way of keeping them involved, and since the final objective of the application is reaching a behavioral exchange, the more participation of a user on the project, the more feedback will they have, enlarging the awareness of the user.

Architecture of the client and server levels

Departing from the conceptual and technical overview obtained in the previous process of analysis, the system to be developed was divided in two main levels, client side and server side.

A basic schema of the levels of the client side, paying attention only to the functionality of the system, could be the corresponding to the picture below:

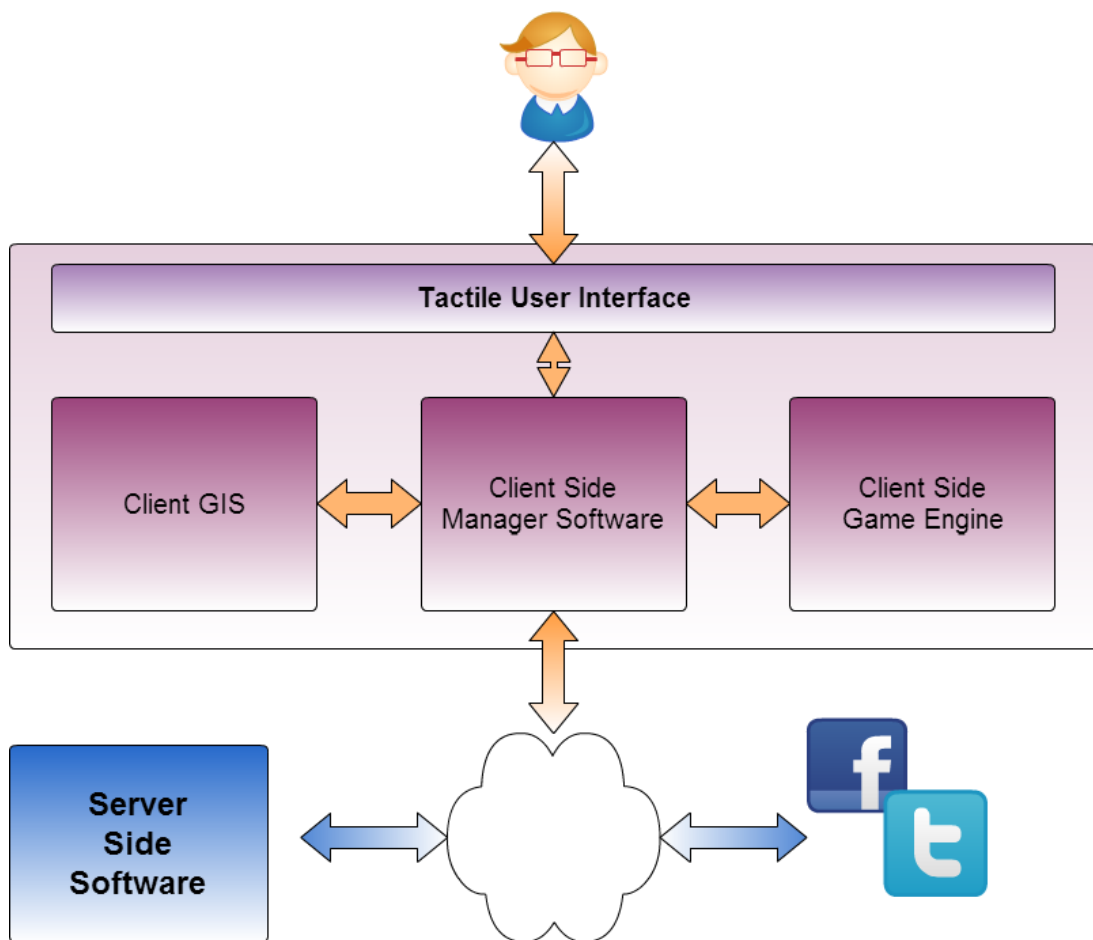


Image 3: Client Side conceptual main components

Of course, this structure is only a functional first-sight diagram, but the Android technology, based on activities and intents make the distance between

interface, modules, databases and logic modules not so clear as in the functional diagram (*Mednieks2011*). The reason is easy to understand: mobile applications are working online, but with mobile connections the availability of the network is not guarantee all the time, and because of this the most important thing to guarantee a good functionality is to keep all the information required for the activities. This property called *persistence* of the information makes necessary a continuous interaction with an own internal database, different from those contained on the server side.

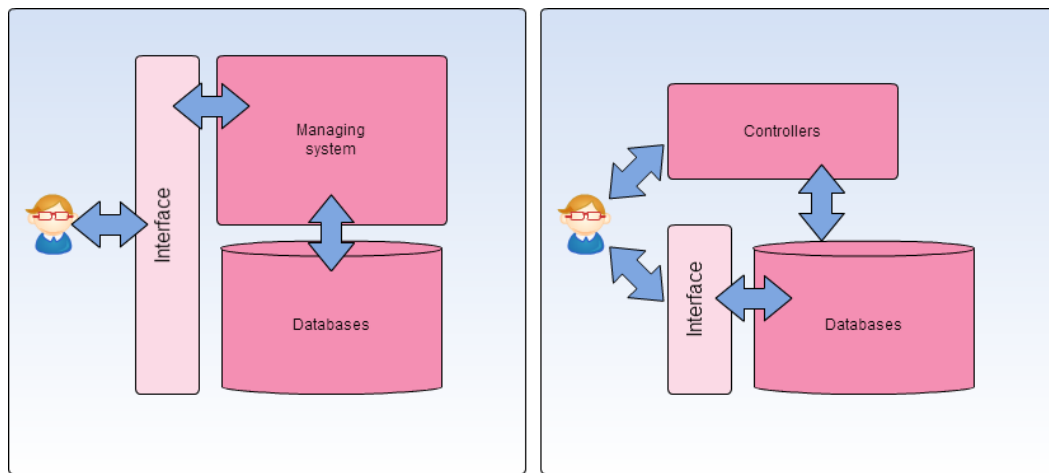


Image 4: Differences between traditional design and Android design

From the point of view of the execution, traditionally the application code used to be run on a process, but Android is based on Java, and thought to run multi-threading code, so the way of running code is also different in this platform.

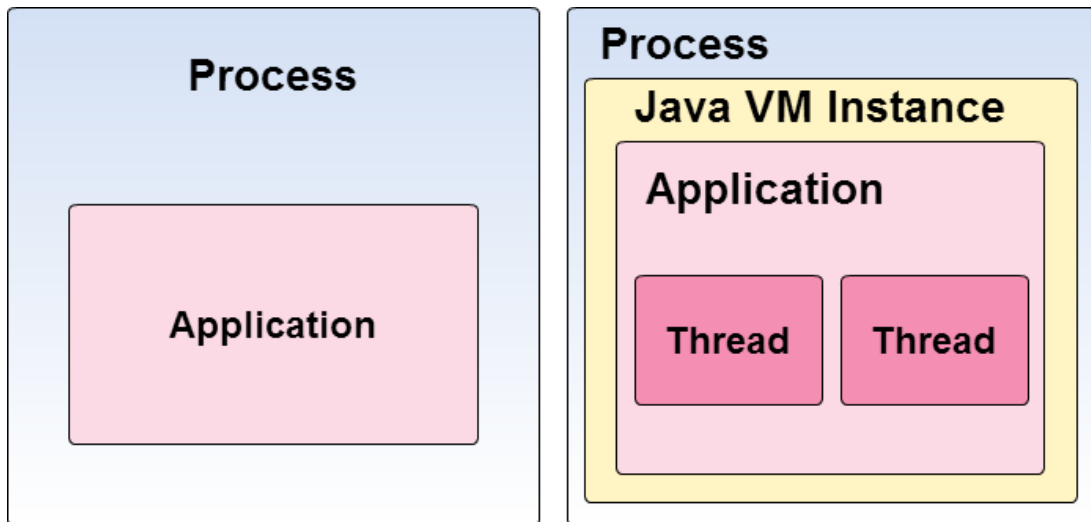


Image 5: Differences running an application on Android and former platforms

Taking into account all this considerations, a new components structure is designed, closer to Android approaches:

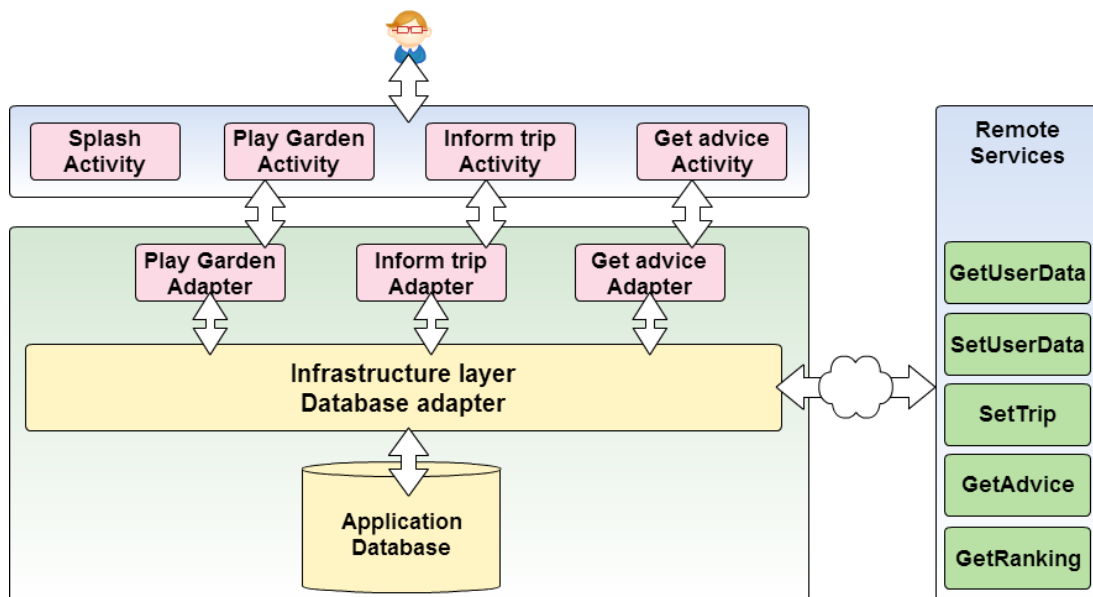


Image 6: Android based structure

On the server side, the functional diagram can be represented by the structure shown in the picture below:

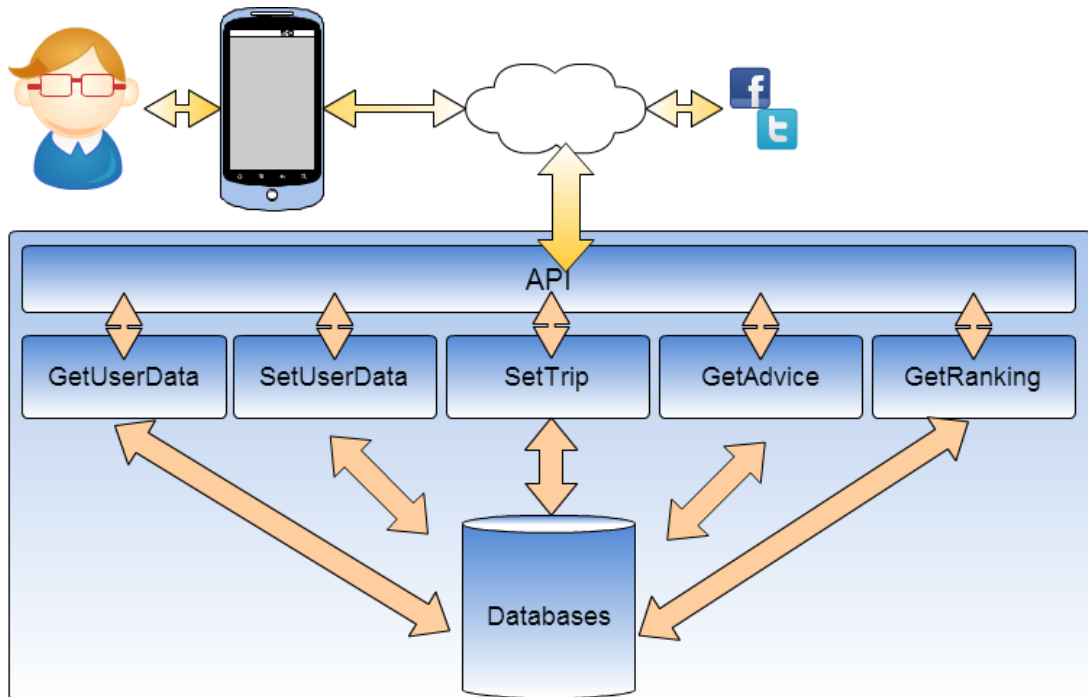


Image 7: Server Side main components

In this case, the API will offer web services to get and provide information to the application running on the client side. The services to be implemented are:

- **SetUserData**: When a user registers for the first time on the application, or if some user data is modified, this service is invoked passing the required information
- **GetUserData**: This service offers the functionality to recover information from a user
- **SetTripData**: This service is employed to send to the server the information referred to a trip that the user has informed to the application, invoked specifying the conveyance, number of persons, origin and destination

- **GetAdviceData**: This service is designed to get advice. Invoked by specifying origin and destination, the service returns the most convenient conveyance
- **GetRankingData**: This service is designed to get the ranking of users

Databases

In order to store all the information collected by the users, and to have a copy of all the information produced by the game, the system will need of a database. The schema of the database (initially on the server side, but some information will have to be replicated in the internal database of the mobile application because of design needs) with the information to be stored could be summarized in the next picture.

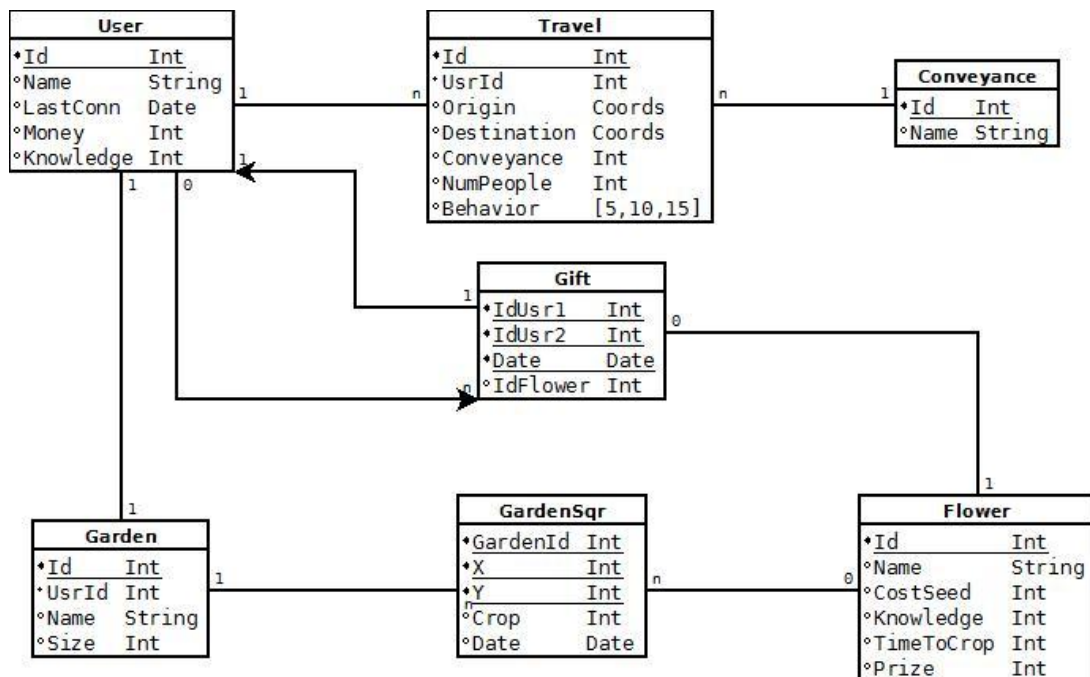


Image 8: Application database

Classes / objects

Departing from the previous considerations, a classes structure have been designed in order to represent all the features included on the design. The structure of classes is shown in the picture below.

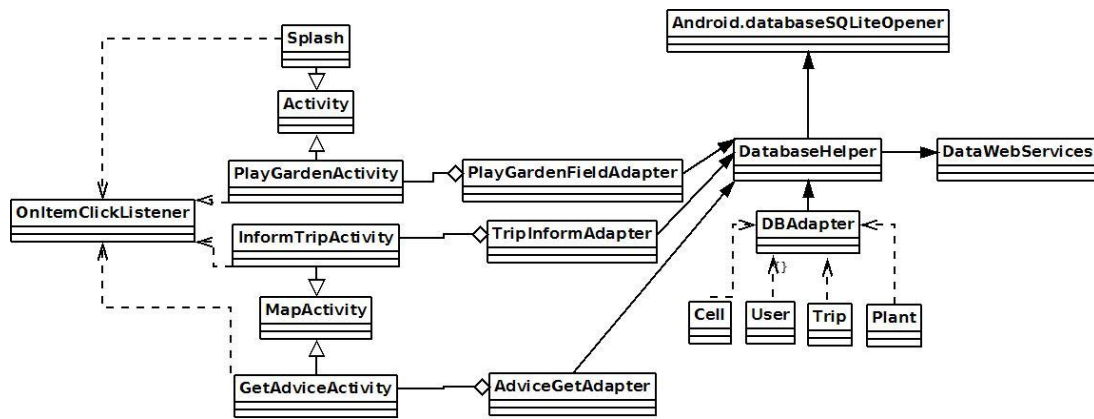


Image 9: Classes diagram

User interfaces

According to the previous considerations, the user interfaces are designed following the storybook of the game and considering the technology chosen. With that specifications, the initial screen of the application will serve the options to the user. Within the options the user will be able to go to play the game, or to inform of a travel (this is the only way to increment their knowledge level), or asking for advice for a travel.

The screen corresponding to the game, allows a view of the garden with the different squares and their status, the amount of money and knowledge and the available seeds to be bought.

Finally, the interfaces of travel informing and asking for advice have a similar aspect and behavior, but once performed the action, the result screens will be different, in the first case it will inform of the increment of knowledge and will offer an evaluation of the behavior, and in the other case the screen of result will recommend an action for the travel to be done.

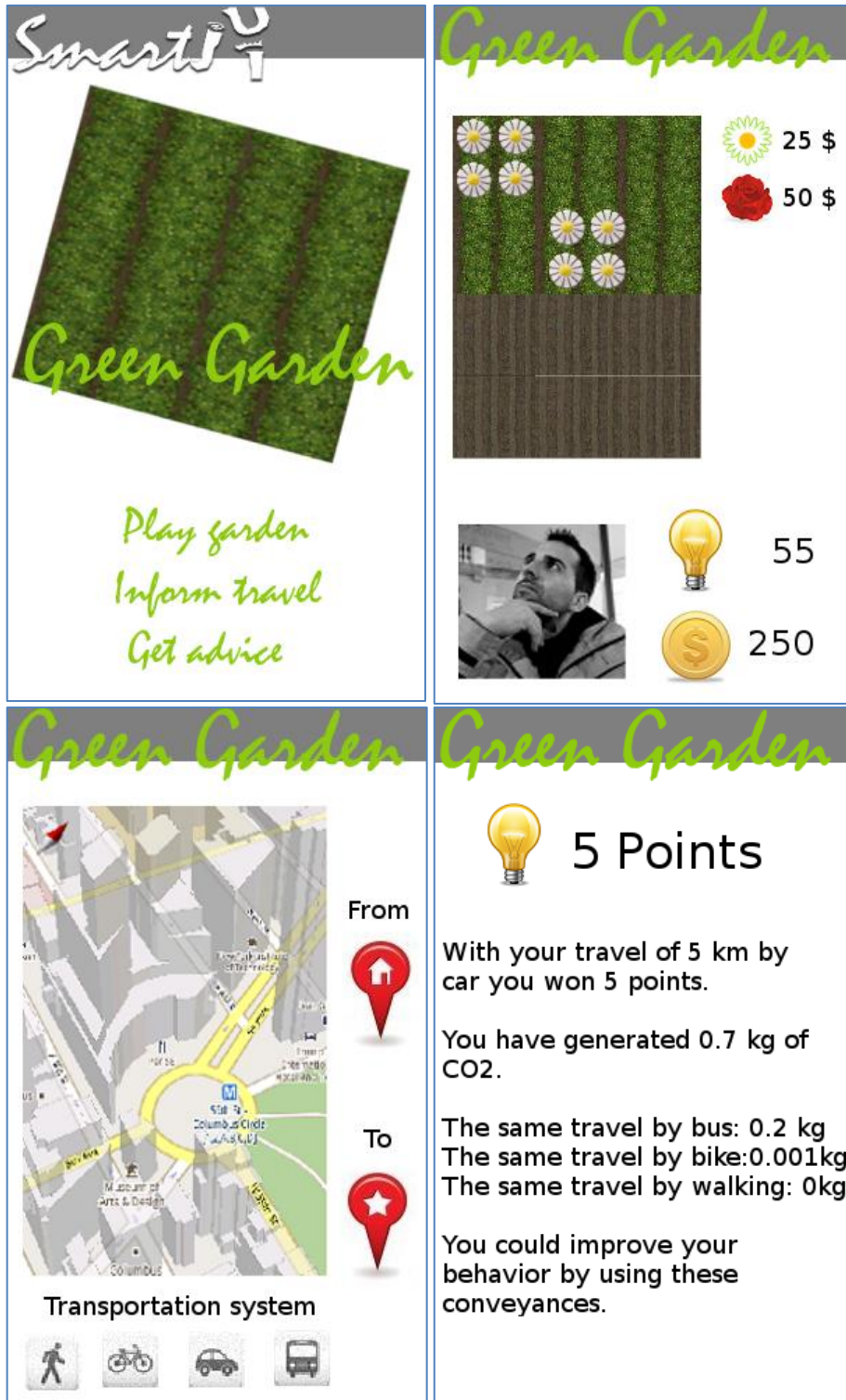


Image 10: User Interface design

CHAPTER 5: RESULTS AND CONCLUSIONS

The project was developed during the third semester of the master, starting on September 2012 and finishing on February 2013. During this time the project dealt with many different tasks, that could be grouped in six main big tasks or groups of tasks:

- **Initial approach**: This first task was the base of the work. The first weeks of the project were dedicated to take contact with the UJI smart campus project and conceiving an initial idea of a project suitable to be incorporated on it
- **Bibliographic review**: This task had two different parts, the first part relative to bibliographic review on previous experiences related with the field of research, and the second part relative to review on gamification techniques and approaches
- **Analysis and design**: This group of tasks includes all the work done in order to analyze the different requirements and design the system according to them
- **Coding and implementation**: This task is really generic. In order to implement the idea it was necessary to get familiarity with the different technologies involved on the project. This caused a lot of time to be invested in a technological training, fact that took an important part of the whole process.
- **Testing**: This group of tasks was developed in two different phases, an initial testing during the implementation of the components and a second testing phase done after finishing them, in order to perform a complete test

- **Thesis writing**: The thesis writing was develop progressively during the different stages of the project

The chronogram of the project is shown in the table below.

	September	October	November	December	January	February
First approach to initial requirements						
Bibliographic review on previous experiences						
Bibliographic review on gamification techniques						
Analysis and design of the system						
Coding and implementation						
Initial testing						
Hosting and integration						
Final testing						
Thesis writing						

Table 2: Chronogram of the project

Finally, after all the work done in analysis, design and planning, the project arrived to the point of the final development of the game. As was explained on the point related to the implementation, to complete this work only a proof of concept was implemented, but not the whole application. This was due mainly to the lack of time caused by the by the effort done in order to get familiarized with the technologies involved on the project, especially mobile technologies. All the tests were oriented towards the main goals of the project: the process of advising the users by the use of the game and the information obtaining from the users. The implementation of this proof of concept is a guarantee of the feasibility of the whole project.

Implementation

As previously said, the main goals of the gamified application developed on this project is double, on the one hand providing a feedback of the green behavior of the users, aiming to allow an increase on users awareness and motivate a behavioral exchange, and on the other hand recollecting information about the habits of transportation of the community.

The concept of the application was designed having in mind this two main objectives, but during the process of gamification, the possibility of getting advice was incorporated to the functionality, and the story of the game incorporates some rules (a ranking of users, the possibility of sharing items...), that are part of the rules designed within the gamification process.

During the implementation, the time required for the whole phase of analysis, documentation, and the lack of expertise and knowledge about the chosen technology, made necessary the adoption of the decision of starting the implementation with a subset of rules, and attending only to the main goals of the project, to implement initially a proof of concept instead of the whole application.

For this proof of concept, the third interface, relative to getting advice, was not implemented, because the functionality and aspect is quite similar to the activity performed to allow the user to inform of a trip. In the same way, the aspects relative to social interaction were not considered for this initial proof of concept.

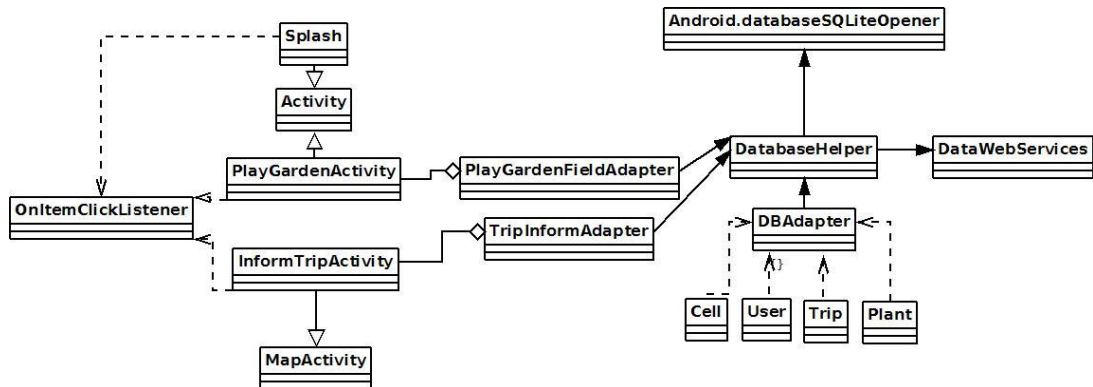


Image 11: Classes diagram of the proof of concept

With these considerations, the implementation of the proof of concept centered the first effort in the implementation of the user interfaces. For the case of the game, initially the user finds an empty garden to be grown, and to start the game, has to select a crop and a garden cell to seed it.

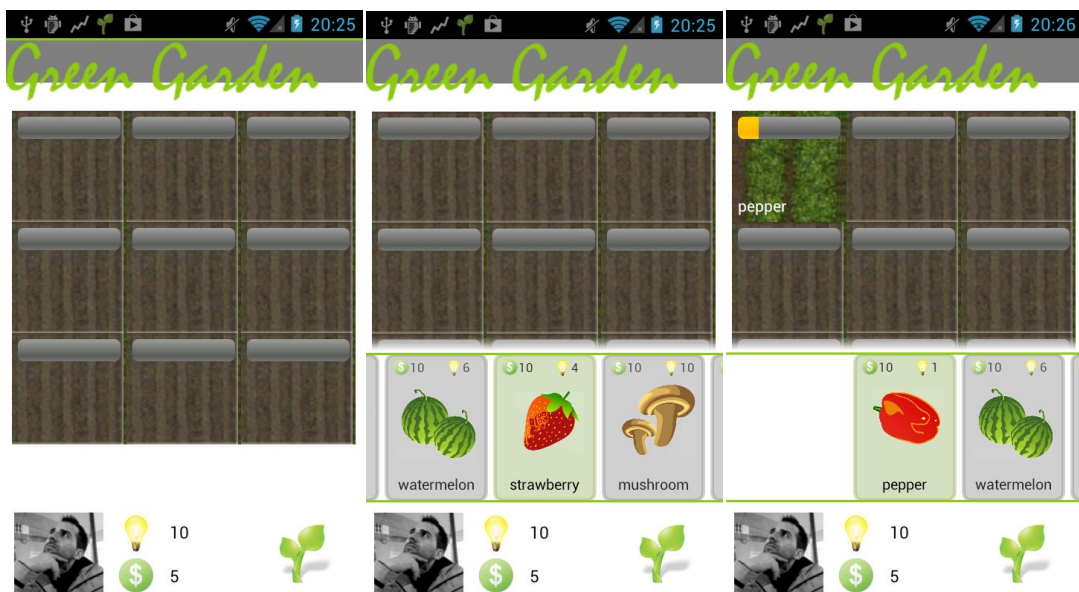


Image 12: Selection of a crop

After performing these actions, the development of the game waits for the growth of the crop. A player might have many different crops growing at the same time, each one in one different cell of the garden. In order to deal with this situation, the application throws a different thread for each active cell, to supervise the growth of the crop on it, and when it is ready, the thread launches an alert to the user in order to advice them to review the garden on the application.

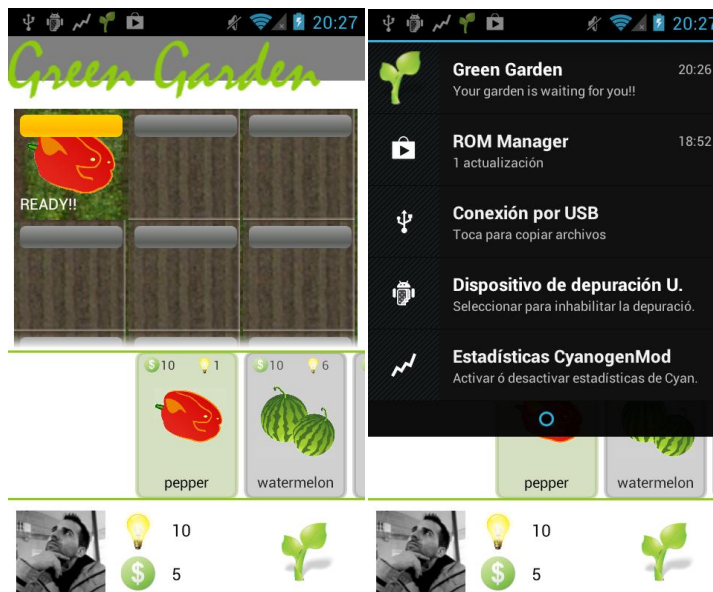


Image 13: Notification

To guarantee the persistence of the information that the application needs to work on the mobile device, a little database (SQLite) have been created to store that information.

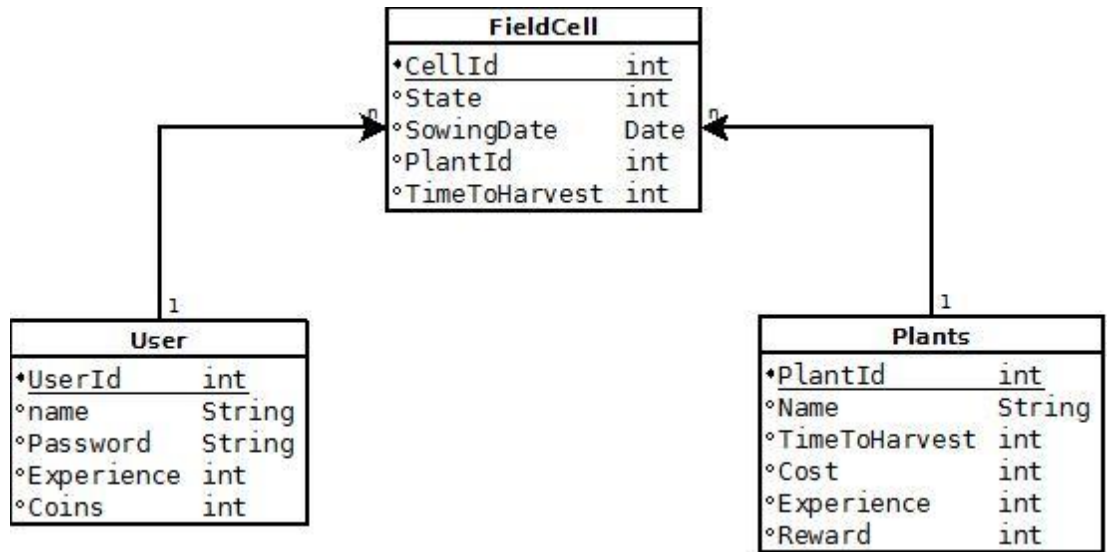


Image 14: SQLite database schema

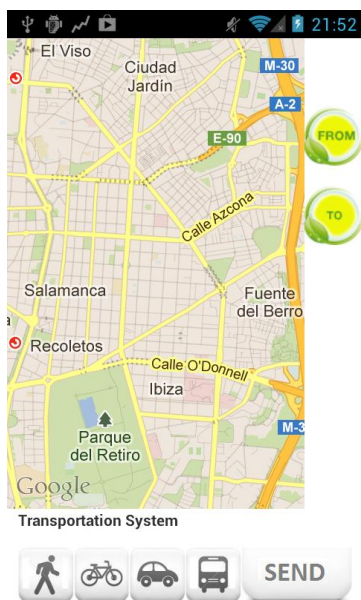


Image 15: Inform travel

To get points of experience, needed to unblock plant seeds, the user informs of their trips through the interface created to inform of a travel. The user selects the origin and destination of their travel, the conveyance used and send the information to the server. The server will evaluate the information sent and will provide a feedback with the evaluation performed, and the points of experience will be updated. The next time that the user comes into the garden interface, the points of experience will be updated.

In order to receive the data from the application and evaluate the behavior of the users, have been created, but they have been reduced to the needed ones to support the functionality of the proof of concepts (SetUserData, GetUserData, SetTripData). The structure of classes is really simple, only two different classes (GreenGardenGets and GreenGardenInserts), one for each different service, containing public methods to support the interface. The way to access to them is through a web service access, specifying the parameters using a web direction, using the get method, for example, to get the user data of the user identified by the identifier zero, the get request would be:

`http://castilloubuntu.aarq.upv.es/GreenGardenGets/index.jsp?
TypeElement=UserData&UserId=0`

For the needs of the proof of concept the parameters to accept are:

- GreenGardenGets
 - TypeElement = [UserData|UserExperience] + UserId
- GreenGardenInserts
 - TypeElement = [Trip] + UserId + Conveyance + LonFrom + LatFrom + LonTo + LatTo + Persons
 - TypeElement = [Coins] + UserId + Coins

Where the parameters correspond to:

- TypeElement: Option to be performed
- UserId: User identifier
- Conveyance: conveyance identifier
- LonFrom - LonTo : Longitude of origin/destination

- LatFrom - LatTo: Latitude of origin/destination
- Persons: number of persons that traveled (only if car was used)
- Coins: number of coins to update the balance of the user

Future work

For the moment only a proof of concept of the application have been implemented in only to proof their viability. As future work it remains enlarge the application to get the whole functionality that was designed on the process of analysis and design, and make it available to the community.

Moreover, some functionalities should be improved. For the moment, in order to evaluate the behavior of the users the services are calculating distances by using the Haversine formula, but there are GIS services that allow to calculate routes and distances taking into account not only the positions, but also the roads, streets and conveyance to be used, features that would be very useful for this project, aiming to integrate the maps and widgets used in the application with those employed by other applications of the *ViscaUII* project.

Conclusions

The raise of the concerns about the environmental problems caused by the transportation systems, and the aim of increasing the general awareness on this field are the basic motivations of this project. With the objective of finding tools to reach an increase of awareness and a behavioral exchange of the members of the community, this project suggested the possibility of implementing an application, within the context of the *ViscaUJI smart campus* project, applying gamification techniques to the process of design in order to involve the biggest possible number of users.

As a result of the analysis and design phases, an Android application integrated on a serious game have been conceived, taking into account all the needed specifications and goals. The implementation of a prototype, gathering the most important requirements and objectives, guarantees the viability of the conceptual design, making possible to assure that the development of such an application is perfectly possible. It remains as future work the improvement to new versions, incorporating all the features added during the design phase and excluded during the implementation of the prototype.

About the evaluation of results of the project, in order to reach valid conclusions, a later process of test involving a number of users from the community as large as possible seems to be the only way of getting a correct evaluation. For the moment the set of data obtained and number of users is still too little to measure the possibilities of achievement of the project within its community frame, however, the results are encouraging, and allow having optimistic expectancies for the future work.

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